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Regional energy planning through SWOT analysis and strategic planning tools. Impact on renewables development

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Abstract

Strategic planning processes, which are commonly used as a tool for region development and territorial structuring, can be harnessed by politicians and public administrations, at the local level, to redesign the regional energy system and encourage renewable energy development and environmental preservation. In this sense, the province of Jaén, a southern Spanish region whose economy is mainly based on olive agriculture, has carried out its strategic plan aiming at a major socioeconomic development. Under the leadership of the provincial government and the University of Jaén, main provincial institutions joined to propose the elaboration of a participatory strategic plan for the whole province. Here, the elaboration of the energy part of the plan, which was directly focused on the exploitation of renewable resources, mainly solar and biomass energy, and which highlights the effectiveness of techniques from business management applied to a sustainable energy model design is presented. Renewable Energy development during the first years of plan execution is presented, and the impact of additional issues is discussed. It is concluded that, although multicriteria decision-making technologies (MCDA) are extensively used in energy planning, a different approach can be utilized to incorporate techniques from strategic analysis. Furthermore, SWOT (strengths, weaknesses, opportunities and threats) analysis has proved to be an effective tool and has constituted a suitable baseline to diagnose current problems and to sketch future action lines.

Keywords: Strategic planning; SWOT analysis; Renewable energy planning

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Contents

1. Introduction

Strategic planning is currently an extended tool for regional development and territorial structuring. Cities, regions and provinces have carried out their strategic plans on the basis of participation processes, which have driven the later development of their territories.

Jaén province constitutes a southern Spanish region of 13,000 km^2 and with more than 600,000 inhabitants belonging to the Andalusian community. Its economy is mainly based on olive agriculture and olive oil production; in fact, Jaén region is currently the world leader in olive oil production. The need for major territorial growth was the key issue for the main political, academic and economic institutions to join and propose the elaboration of a participatory strategic plan in order to foster socioeconomic development of the whole province. The document that was finally released in June 2000, designed a future growth based on dynamism, natural resources preservation and environmental quality [1].

Processes and tools, used to elaborate the energy part of the strategic plan for Jaén province (SPJP), are presented and the efficiency of techniques from entrepreneurial management sciences for the design of a new energy model, more sustainable and environmentally respectful is emphasized. The use of planning tools usually constrained to business administration has reproved to be a useful help for renewable energy sources (RES) planning and further development.

RES advance in the plan execution period is also presented, and the impact of additional issues are discussed. In this way, the influence of other elements–the existence of a PV R&D group at Jaén University, the role of the provincial Energy management Agency and the changes in national legal frame for PV electricity retribution–PV development drivers is assessed.

2. Renewable energy planning techniques at the regional level

Different approaches have been used for renewable planning purposes at the regional level. We present in this section some examples of remarkable ways to address sustainable planning. Multicriteria decision techniques, Delphi surveys and territorial energy planning constitutes the most referred approaches on literature.

2.1. Multicriteria decision techniques

Multicriteria decision techniques were developed profusely in the 1960s. Classic methods came from that decade in which goal programming and elimination and choice translating reality (ELECTRE) methods were proposed. In the 1970s, new methods and refinements of existing ones were developed, and finally in the 1980s, support from computer sciences has allowed a fast growth in applications and results from multiple criteria decision-making (MCDA) techniques.

Under the scope of the energy, initially one-criteria approaches were used for planning purposes, focused on demand forecast and the search of an efficient low-cost supply forms. Nevertheless, since early 1980s, the need to incorporate social impact and environmental issues on energy planning has encouraged the use of multicriteria decision techniques. Data compiled by Pohekar and Ramachandran [2] shows that Analytical Hierarchy Process (AHP), Preference ranking organization method for enrichment evaluation (PROMETHEE) and ELECTRE method have been widely used in energy planning. They reviewed and analyzed more than 90 published papers and concluded, concerning MCDA methods, that AHP is the most popular technique, followed by PROMETHEE and ELECTRE.

ELECTRE method is based on the outranking relations established between each pair of alternatives. Concordance matrix and discordance matrix are then elaborated to generate a selection or a ranking of the different alternatives. It has been successfully used for renewable energy planning as shown by Beccali et al. [3]. They assessed an action plan for the diffusion of renewable energy technologies at the regional scale, using a multicriteria approach with 12 evaluation criteria.

2.2. Delphi techniques

Delphi techniques have also been a popular tool for preparing forecasts and planning purposes. It is being used as an effective method in long-term planning related to sustainable development In this sense, Shiftan et al. [4] suggest the use of two scenarios constructed by means of a Delphi expert-based survey. Other authors, as Popper and Dayal [5] propose the utilization of Delphi, assisted by a web-based survey, combined and supported by a geographical information system (GIS) to promote sustainable development in developing countries.

2.3. Territorial and rural energy planning methods

Participatory approaches for energy planning implementation have been extensively used in rural areas and developing countries. Example for a rural energy development planning in India is presented by Neudoerffer et al. [6], who verify that energy programmes launched by Indian government have got limited success due to the lack of mechanisms to assure the implication of final users, and present the main conclusion of a research project to develop planning methodologies and tools to facilitate public participation. Anderson and Doig [7] also highlight the importance of participation techniques to implement, in a successful way, energy plans and projects at rural areas.

The case of Jaén province, which is presented in this article, confirms the suitability of these kinds of approaches when society implication is essential.

3. The strategic plan for Jaén province

Elaboration of the SPJP began with the commitment of the provincial government in the project. In 1997, provincial authorities formally approved the proposal to elaborate a strategic plan to foster territorial development. Since this proposal, a negotiation process started among most relevant institutions in order to shape the initial idea, to establish the structure and to define organization and project terms.

Both the provincial government and the University of Jaén took lead of the project and created a foundation called "strategies for economic and social development of Jaén province" that took charge of the whole project management. This was the starting point for most relevant institutions at the provincial level to join to the newly created foundation and collaborate in the ambitious project of territorial strategic planning.

A sequentially phased programme was established (Fig. 1), trying to assure, on one hand, the technical consistency of the plan and, on the other hand, the massive participation of the provincial community. Technical consistency was pursued through a diagnosis phase based on expert working groups, and the implication for the community was addressed by means of a collective participation phase specifically designed to encourage participation in working tables. Political implication and commitment was also pursued. In this way, an approval phase, where each political institution assumed its compromise with plan execution, was finally carried out.

The project was finally achieved in June 2000. It designed a future regional growth based on dynamism, natural resources preservation and environmental quality [1]. The strategic plan was finally approved by the Foundation Management Board in July, 2000. It was structured through the following: a general objective, four strategic axes, 34 promotion programmes, a 163 performance lines and 215 strategic projects.

From the main objective statement, "to transform Jaén into an economically dynamic province, territorially balanced, socially focused on solidarity, advanced and culturally creative, committed to environment preservation, bastion and point of reference for olive oil, interior tourism and environmental quality", the plan guides the desirable provincial energy system towards a sustainable model, based on autochthonous resources mainly from the olive oil industrial sector.

During the subsequent deployment, such a model is materialized in five promotion programmes, 12 performance lines and 19 strategic projects oriented in a specific way towards the provincial energy structure redesign and the bid for renewable energy.

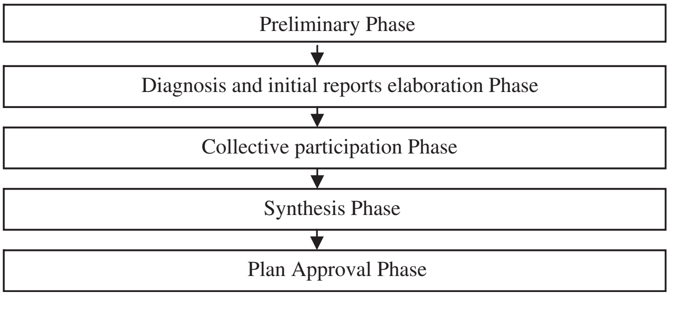


Fig. 1. Strategic plan development phases.

4. Development of energy planning

At the beginning of the diagnosis phase, a series of technical expert groups was appointed in each of the technical areas to be addressed by the strategic plan (Table 1). One of these groups was responsible for analyzing the territory status within the area of infrastructures, energy, urban development and environment. It was constituted in December 1998, including representation from the university, the energy agency and the provincial government. Group members maintained up to 22 working meetings during the whole process and they elaborated first, in 4 months, an initial report that was issued and presented publicly.

Afterwards, a collective participation phase began, and the technical report was put for later discussion to allow collaborators, who voluntarily had become involved in the reflection process, to analyze it and to contribute new ideas to the debate. Finally, the technical group reprocessed the initial report, collecting the contributions and the suggestions of the collaborators, incorporating new proposals, clarifying some of the existing ones, and omitting those that were not considered pertinent. The final document concerning the energy area was approved in the month of March, 2000.

It is important to emphasize that the work sessions followed an interdisciplinary method, where ideas exposed by anyone of the group members were submitted to different scientific and/or technical interpretations from any other field. In this way, results were enriched by the manifold approaches under which the proposals were analyzed.

The diagnosis of the energy system was structured through a SWOT matrix (Table 1), in which the weaknesses, strengths, threats and most relevant opportunities that must be faced by the provincial energy system were shown. This kind of analytic tool is often used in participatory planning approaches, although it was originally developed for strategic planning in business and marketing purposes. It must be taken into account that SWOT is only a tool and has to be based on a sound knowledge of the present situation and trends (Table 2).

SWOT analysis for energy allowed to establish, as the following step, problems that had to be faced by the energy area, as well as the suitable strategies that could overcome such problems. For this purpose, a *problems tree* was elaborated (Fig. 2), arranging in the form of a family tree the main weaknesses of the provincial energy system, grouping them under

Table 1
Technical areas within strategic plan development

Technical area	Number of experts	Number of meetings
Society and labour market	6	24
Infrastructures, energy, urban development and environment	5	22
Olive agriculture and olive oil production	4	8
Industry	6	18
Trade business	2	10
Tourism	3	10
Culture	6	11
Technical report: Cattle raising and other agriculture	1	

Table 2
SWOT matrix for energy

Strengths	*Weaknesses*
F.1 High solar radiation	D.1 Lack of fossil energy resources
F.2 Large amount of agricultural and industrial biomass	D.2 Limited installed power for electrical generation
F.3 High exploitation of hydroelectricity in Guadalquivir river basin	D.2 Insufficient infrastructure for natural gas distribution
F.4 Great tradition in solar energy research and development	D.4 Low sensitiveness to energy saving
F.5 Existence of the energy management agency of Jaén province	D.5 There is no individual awareness for Renewable Energy utilisation
F.6 High value of natural heritage, that favours clean energies development	D.6 Buildings are not constructed with bioclimatic criteria
	D.7 Renewable energy business sector is weak
	D.8 Low quality of electricity on determined areas
	D.9. Absence of financial mechanisms to endeavour RES penetration
	D.10 Dependency of an unique high voltage injection to the provincial electricity network
Opportunities	*Threats*
O.1 Existence of industrial sectors suitable for installing cogeneration processes	A.1 Progressive environmental deterioration
O.2 Suitable climate for the successful application of bioclimatic criteria	A.2 Excessive dependency on fossil fuels
O.3 Existence of applicable funds to invest in energy system development	A.3 Risk of energy resources price increase
O.4 Existence of susceptible areas for wind energy development	
O.5 Existence of subsidies to electricity production with renewable sources in the new Spanish electrical market	

the headline: "*Centralized energy system, incomplete, hardly respectful with the environment and with scarce autochthonous resources utilization*".

Directly derived from that *problems tree*, as an *objectives tree* was depicted that allowed to obtain the strategies and performance lines routed to the solution of detected problems. This *objectives tree*-structured strategies came under the general mission: "*To improve the energy efficiency and the energy supply conditions as local development and environment conservation element*". Finally, in the third place, each one of the strategic projects designed to reach the previously outlined objectives were presented .

Despite the fact that the most usual tools in energy planning are based on multicriteria decision analysis techniques that have demonstrated their effectiveness in a significant amount of situations [2], the use of SWOT analysis in the development of the strategic plan permitted a correct comprehension of the provincial energy situation and served as a basis for objectives and strategies proposal. In fact, the use of SWOT analysis encouraged the discussion and criteria contrast among group members in the elaboration process of the sectors of the matrix as well as in the subsequent review for the development of the problems tree and the objectives tree. This quality, already commented on by some authors [8], favoured the elaboration of the diagnosis and the interdisciplinar coherence.

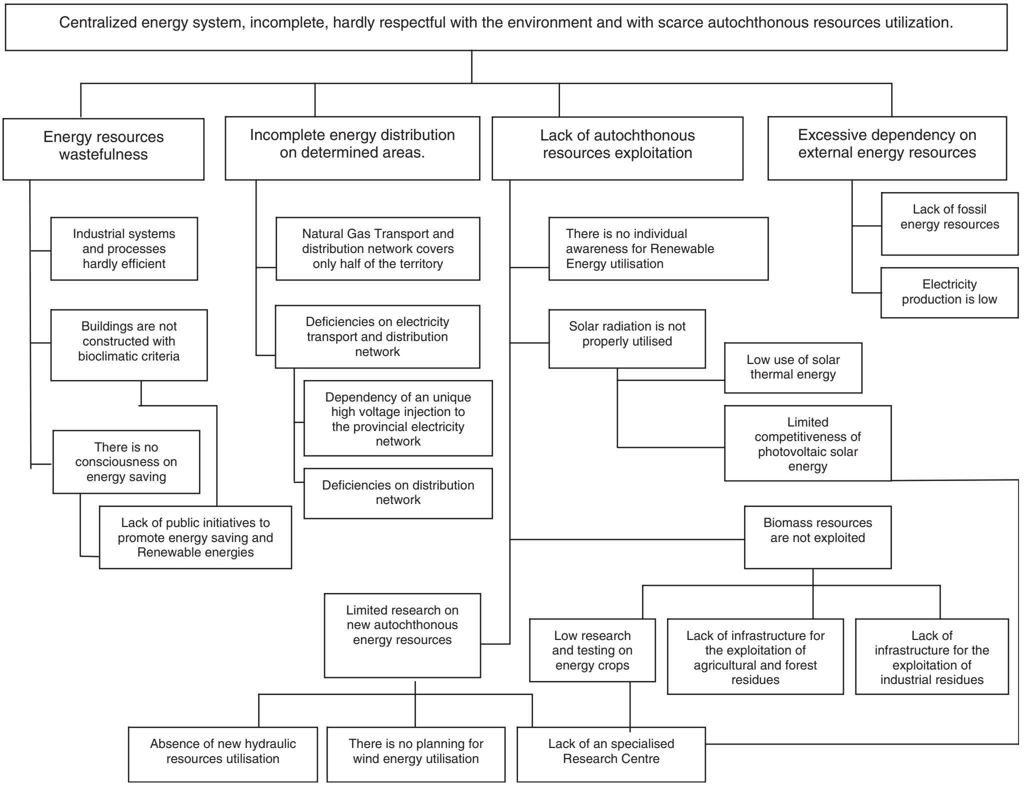


Fig. 2. Problems tree of provincial energy system.

5. Final structure of the plan

Along the synthesis phase, the strategic plan was structured as a deployment of promotion programs, performance lines and strategic projects (Table 3).

Project definition included, in most of the cases, the quantification of the objective goals (Table 4). Among these objectives, the following can be highlighted: the installation of 100 MW of power in plants electrical generation with biomass; to reach 1 MW of PV grid-connected installed power; to obtain the annual installation of 10,500 m^2 of thermal solar panels; or to reach 50 MW installed in Wind Energy systems.

The quantification, in terms of energy, of the specifically set strategic plan goals, lead us to foresee an electricity yield of 1226 GWh from renewable sources (Table 5). It is interesting to check that this figure matches the extrapolation to provincial level, using the population as extrapolation ratio, of the Spanish and Andalusian objectives set by the respective energy plans.

The National Renewable Energy Plan [9], published by the Spanish government in 1999, fixed a national goal for the electricity yield from renewables of 76,597 GWh by 2010, and the Andalusian Energy Plan [10] has recently established a regional goal of 12,356 GWh. Taking into account that the Jaén region population is 1.62% out of the Spanish

Table 3
Final structure of the energy part of the Plan [1]

Promotion programmes	
Program 3.	Improvement of infrastructures that support provincial industry
Program 5.	To drive a sustainable model for economic development
Program 25.	Diversification of infrastructures, urban spaces and natural ecosystems
Program 26.	Fitting, improvement and maintenance of infrastructures and natural and urban heritage
Program 27.	To stimulate a larger social and political awareness on urban development, infrastructures, and environmental scopes.
Performance lines	
03.3.	To increase current infrastructures network
05.1.	Exploitation and utilization of by-products and residues, from agriculture and industry
05.3.	To favour a sustainable development model at provincial Natural Parks
25.6.	To increase the installed capacity for electricity generation
25.7.	Exploitation of autochthonous energy resources
25.8.	Extension and improvement of natural gas supply
26.6.	Improvement of electricity supply
26.7.	Saving and energy efficiency
27.5.	Increase of the environmental policies efficiency and impulse of local administration environmental management
27.6.	Impulse of the shared responsibility concept in the solution of the territorial environmental problems
27.7.	Social and political implication for the efficient and rational use of energy resources
27.8.	Improvement and diffusion of knowledge concerning environment and sustainable use of natural resources

population and 8.92% of the Andalusian population, a simple extrapolation gives us reference figures of 1240 and 1102 GWh, respectively.

The energy diagnosis of the plan [11] concluded fixing as the long-term high-priority items the energy diversification, fundamentally based on natural gas and autochthonous renewable resources, the improvement of gas and electricity networks, the political and social awareness to drive an environment-friendly energy development, and the research and education on renewable energy matters.

6. Key issues in the planning process

Three issues can be highlighted as the most important for planning success purposes: community participation, interdisciplinarity and SWOT methodology.

Participation of the community was the most important factor for the successful completion of the strategic plan. More than 500 people were involved in the whole strategic plan development, coming from different business sectors, universities, local administrations, etc. With respect to the energy area, more than a hundred people were members of the Energy collaborators board.

Interdisciplinary method followed by the expert group work sessions was also fundamental in assuring scientific consistency. Proposals and new ideas were submitted to different scientific and/or technical interpretations.

Finally, methodology based on SWOT analysis for the diagnosis of the energy system assured a comprehensive outline of the regional energy situation and a complete set of strategies deployment (Table 6).

Table 4
List of strategic projects and goals defined [1]

Strategic projects		Goal to meet
015.	Extension of natural gas transport and distribution network	80% of population
016.	To increase the capacity of the high and medium voltage electricity grid, to guarantee supply and industrial development	—
019.	Exploitation of biomass resources for the installation of electricity generation plants	100 MW
020.	Installation of cogeneration plants in thermal energy consuming industrial sectors	130 MW
021.	Establishing of the necessary structures for the complete exploitation of agricultural and forest residues	Y/N
022.	Establishing of the necessary structures for the energy exploitation of residues from cattle raising and industry	Y/N
023.	Wind energy planning of Jaén province	50 MW
024.	Promotion of solar photovoltaic grid-connected systems	1 MW
025.	Promotion of energy crops in marginal lands	—
121.	Legal normative to encourage domestic solar water heating systems in new buildings	10,500 m^2
122.	To increase the use of isolated PV systems for the electrification of rural housings and facilities	Y/N
123.	Application of energy saving and efficiency criteria in buildings	—
124.	To encourage the recovery of small hydraulic plants	Rehab. Plan
125.	To transform AGENER into the provincial energy agency	Y/N
145.	Installation of a second 220 kV injection to electricity transport grid	Y/N
146.	Improvement of the electrical distribution grid to increase supply quality TIEPI = 2.11	
154.	Diffusion and training campaigns in energy saving and renewable energies	Y/N
155.	Research and technological development institute dedicated to exploitation and conservation of natural resources	Y/N

Table 5
Electrical generation objectives of the strategic plan

	Goal 2007 (MW)	Equivalent hours	Electricity yield (GWh)
Hydraulics ($P<10$ MW)	60	2000	120
Hydraulics ($P>10$ MW)	137.56	1850	254.49
Wind energy	50	2295	114.75
Biomass	100	7353	735.3
Solar photovoltaic	1	1514	1514
Total energy yield			1226.05

7. Impact on energy system and RES development

The reality defined in the energy diagnosis of the plan was a firm and accurate basis to advance and to enhance the energy structure. The situation shown by SWOT matrix reveals the real status of the energy system and could be, with broad strokes, applicable to

Table 6
Participation and working table meetings held

Working table	Number of participants	Number of meetings
Society and labour market	123	6
Infrastructures, energy, urban development and environment	119	8
Olive agriculture and olive oil production	46	3
Industry	63	4
Trade business	26	2
Tourism	76	3
Culture	118	7

present situation [12], although it must be highlighted that in many aspects, mostly related to RES development, it has improved considerably and the region is on the way to settling many of the weaknesses expressed in the document.

Regarding the electricity supply system, we can verify that the electrical generation capacity has been improved, through the installation of about 80 MW of new power, out of which 30.5 MW corresponds to biomass and biogas facilities; 15.2 to wind energy farms; 0.64 of PVGC and the rest to cogeneration plants. It has also improved the quality of supply, the infrastructure for natural gas supply has been increased and it is in the process of solving the weaknesses of the electricity transport and distribution network.

In this way, the amount of electricity produced in the province of Jaén during the year 2003 covered more than 40 per cent of consumed electricity, and a half of this percentage was obtained by means of autochthonous renewable resources (hydraulic, biomass, wind and photovoltaic). Evolution of the energy system, concerning RES electrical generation, is shown in Table 7. It can be noticed that an electricity yield of 369 GWh by renewable sources (without taking into account hydraulics[1] plants) would represent 14.25 per cent of total electrical energy consumption, having increased the contribution by 140 per cent in the last 4 years.

A remarkable behaviour has currently been observed in PV development. In the last 3 years, Jaén province has been able to triplicate the total amount of PVGC power installed. The number of grid-connected systems has increased from two plants adding up to 200 kW in the year 2000 to 14 plants amounting to more than 600 kW, while stand-alone systems are maintaining a steady growth. In this way, the objective fixed in the plan has nearly been attained.

For the next years, expectations are even better as more than 1500 kWp are currently being projected. The implication of local governments and the financial support from national and regional programmes has also assisted in the improvement achieved, taking advantage of the opportunity shown on the SWOT matrix.

In March 2004, the Spanish Royal Decree 436/2004 [13] revised the economical regime for the electricity produced by renewable sources. The contribution for the electricity from PV systems up to 100 MW, that is currently fixed to 0.421498 €/kWh, was improved. This new legal frame has been one of the key issues to encourage new projects and installations.

[1]Data on Hydraulics has been segregated between Hydraulics plants (more than 10 MW) and Minihydraulics (10 MW or less).

Table 7
Evolution of the contribution of RES to electrical generation

	2000	2001	2002	2003	2004	Growth
Hydraulics $P>10$ MW (MW)[1]	137.56	137.56	137.56	137.56	137.56	0
Hydraulics $P<10$ MW (MW)	52.2	52.2	52.2	52.2	52.2	0
Wind power (MW)	0.0	0.0	9.2	15.2	15.2	15.2
Biomass and biogas (MW)	0.0	9.5	25.5	25.5	30.5	30.5
PV grid connected (MW)	0.20	0.20	0.21	0.26	0.64	0.44
Estimated yield (MWh)[a]	321,500	388,600	525,900	540,300	575,900	79.09%
Estimated yield without [1] (MWh)	115,200	182,200	319,500	333,000	369,600	220.72%
Provincial consumption (MWh)	1,934,584	2,124,466	2,286,479	2,470,760	2,594,300	34.10%
RES contribution (%)	16.62	18.29	23.00	21.87	22.20	33.55
RES contribution without [1] (%)	5.96	8.58	13.97	13.52	14.25	139.16

[a]Electricity yield estimated through annual equivalent hours applied to installed power.

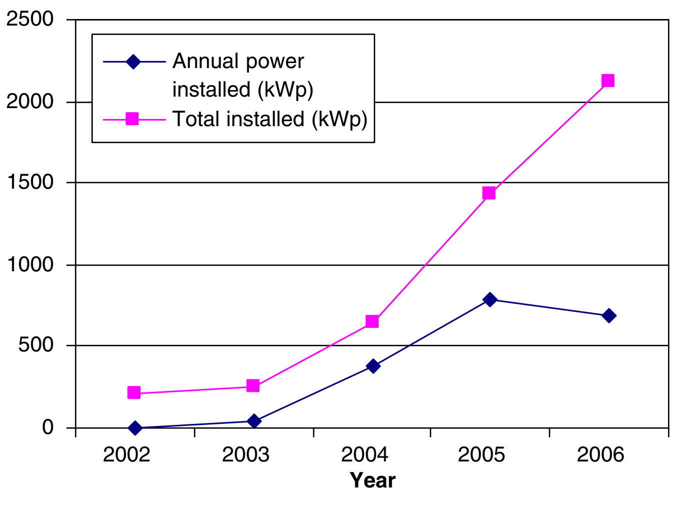


Fig. 3. Committed growth for PV grid-connected systems.

Moreover, on the local side, a collaboration agreement has been recently signed among the provincial government, the energy management agency and the official credit bank in order to foster the implication of local municipalities in renewable energy projects, through technical assessment and low interest rate bank loans. Following the agreement signature, a significant number of municipalities, assisted by the energy agency, have begun to plan and build PVGC systems.

Analyzing the growth already achieved by grid-connected systems (Fig. 3) and assuming a ‘‘business as usual’’ scenario for stand-alone PV systems, Jaén province will definitely see the amount of 2500 kWp being installed by the year 2006. This figure represents a ratio of 1 kWp per 260 inhabitants. If we make an extrapolation of this ratio to the whole country, it would mean a total amount of 154 MWp installed by the year 2006, while the goal fixed in the Spanish National Plan for Renewable Energy promotion is 144 MW, to be reached

in the year 2010. Therefore, Jaén province will be achieving in 2006 a 107 per cent of its contribution of the National goal established for year 2010.

8. Conclusions

Management tools habitually used in territorial strategic planning processes can be used by public administrations as suitable tools to search and select strategies that may help them in the redesigning of the regional energy system.

Although most usual tools in energy planning are based on multicriteria decision-making techniques, SWOT analysis has resulted in a successful tool for energy planning when experts' discussion and interaction is needed and a set of strategies should be agreed upon.

Designing of SWOT matrix applied to the energy system of Jaén province was a suitable baseline to diagnose current problems and to sketch future action lines. It has supported the process of strategies proposal and definition, encouraging debate and confrontation of criteria among group members and finally favouring diagnosis elaboration and interdisciplinary coherence.

Energy planning derived from the strategic plan of Jaén province has resulted in a driving factor for the encouragement and addressing of RES development at the local level. In the early years of strategic plan execution, Jaén province has been able to achieve in a significant part of the objectives defined in the energy area. In this way, contribution of the renewable resources to the provincial energy structure has grown significantly. RES electricity generation has increased by 220 per cent, with an outstanding behaviour of PVGC system, which installed power, have been triplicated in recent years.

As a consequence, we can assert that objectives derived from the Spanish National Plan for Renewable Energies promotion [9] will be achieved at the regional level, and the path to comply with the European Commission White Paper [14] and with the objectives-derived EC directive on electricity from RES [15] is pointed out.

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